Chapter 11

The Sensory System
Overview
<table>
<thead>
<tr>
<th>Key Terms</th>
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<tbody>
<tr>
<td>accommodation</td>
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<tr>
<td>astigmatism</td>
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<tr>
<td>auditory tube</td>
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<tr>
<td>aqueous humor</td>
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<tr>
<td>cataract</td>
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<tr>
<td>choroid</td>
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<tr>
<td>cochlea</td>
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<tr>
<td>conjunctiva</td>
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<tr>
<td>convergence</td>
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<tr>
<td>cornea</td>
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<td>glaucoma</td>
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<td>gustation</td>
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<td>hyperopia</td>
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<td>iris</td>
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<tr>
<td>kinesthesis</td>
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<tr>
<td>lacrimal apparatus</td>
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<tr>
<td>lens (crystalline lens)</td>
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<tr>
<td>macula</td>
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<tr>
<td>myopia</td>
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<tr>
<td>olfaction</td>
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<td>ossicle</td>
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<tr>
<td>proprioceptor</td>
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<tr>
<td>refraction</td>
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<tr>
<td>retina</td>
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<tr>
<td>sclera</td>
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<tr>
<td>semicircular canal</td>
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<tr>
<td>sensory adaptation</td>
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<tr>
<td>sensory receptor</td>
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<tr>
<td>spiral organ</td>
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<tr>
<td>strabismus</td>
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<tr>
<td>tympanic membrane</td>
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<tr>
<td>vestibule</td>
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<td>vitreous body</td>
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</table>
The Senses

Learning Objectives

1. Describe the functions of the sensory system.

2. Differentiate between the different types of sensory receptors, and give examples of each.

3. Describe sensory adaptation, and explain its value.
The Eye and Vision

Learning Objectives

4. List and describe the structures that protect the eye.

5. Cite the location and the purpose of the extrinsic eye muscles.

6. Identify the three tunics of the eye.

7. Describe the processes involved in vision.

8. Differentiate between the rods and the cones of the eye.

9. List seven disorders of the eye and vision.
Learning Objectives

10. Describe the three divisions of the ear.

11. Describe the receptor for hearing, and explain how it functions.

12. Compare the locations and functions of the equilibrium receptors.

13. Describe three disorders that involve the ear.
Other Special Sense Organs

Learning Objective

14. Discuss the locations and functions of the sense organs for taste and smell.
The General Senses

Learning Objectives

15. Describe five general senses.

16. List five approaches for treatment of pain.
Learning Objective

17. Referring to the case study, discuss the purpose and mechanism of a cochlear implant.
18. Show how word parts are used to build words related to the sensory system.
The Senses

- The sensory system provides awareness of our external and internal environments.
  - Environmental change (stimulus) initiates nerve impulse.
  - Stimulus interpreted by the cerebral cortex.
  - Sensation experienced.
The Senses (cont.)

Sensory Receptors

- Receptor classification based on structure
  - Free dendrite
  - End organ
  - Specialized cell
- Receptor classification based on stimulus
  - Chemoreceptor
  - Photoreceptor
  - Thermoreceptor
  - Mechanoreceptor
# The Senses (cont.)

## Special and General Senses

<table>
<thead>
<tr>
<th>Special Senses</th>
<th>General Senses</th>
</tr>
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<tbody>
<tr>
<td>Vision</td>
<td>Pressure</td>
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<tr>
<td>Hearing</td>
<td>Temperature</td>
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<tr>
<td>Equilibrium</td>
<td>Pain</td>
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<tr>
<td>Taste</td>
<td>Touch</td>
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<tr>
<td>Smell</td>
<td>Sense of position</td>
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</tbody>
</table>
Sensory Adaptation

- Receptors often become less sensitive to a continuous unimportant stimulus.
Checkpoints

11-1 What is a sensory receptor?

11-2 What are some categories of sensory receptors based on type of stimulus?

11-3 How do the special and general senses differ in location?

11-4 What happens when a sensory receptor adapts to a stimulus?
The Senses (cont.)

Pop Quiz

11.1 Which of the following is a special sense?
   A) Pressure
   B) Taste
   C) Touch
   D) Proprioception
Pop Quiz Answer

11.1 Which of the following is a special sense?
A) Pressure
B) Taste
C) Touch
D) Proprioception
The Eye and Vision

Learning Objectives

4. List and describe the structures that protect the eye.

5. Cite the location and the purpose of the extrinsic eye muscles.

6. Identify the three tunics of the eye.

7. Describe the processes involved in vision.

8. Differentiate between the rods and the cones of the eye.

9. List seven disorders of the eye and vision.
The Eye and Vision (cont.)

Protective Structures of the Eye

- Bony orbit
- Eyelids
- Eyelashes
- Eyebrows
- Lacrimal glands
- Conjunctiva
Figure 11-1 The eyelid and lacrimal apparatus.
Figure 11-2 A sagittal view of the eye orbit.
Muscles of the Eye

- Adjust eye so the retina receives clear image
  - Extrinsic muscles
    - Outer surface of eyeball
    - Voluntary
    - Control convergence for three-dimensional vision
What characteristics are used in naming the extrinsic eye muscles?
The Eye and Vision (cont.)

Nerve Supply to the Eye

- **Sensory**
  - Optic nerve (CN II)
  - Ophthalmic branch of trigeminal nerve (CN V)
- **Motor**
  - Oculomotor nerve (CN III)
  - Trochlear (CN IV)
  - Abducent (CN VI)
The Eye and Vision (cont.)

Checkpoints

11-5 What are five structures that protect the eye?

11-6 What is the function of the extrinsic eye muscles?

11-7 Which cranial nerve carries impulses from the retina to the brain?
The Eye and Vision (cont.)

Structure of the Eyeball

- Eyeball has three separate coats (tunics).

<table>
<thead>
<tr>
<th>Fibrous Tunic</th>
<th>Vascular Tunic</th>
<th>Nervous Tunic (Retina)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclera</td>
<td>Choroid</td>
<td>Rods</td>
</tr>
<tr>
<td>Cornea</td>
<td>Ciliary muscle</td>
<td>Cones</td>
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<td></td>
<td>Suspensory ligaments</td>
<td></td>
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<tr>
<td></td>
<td>Iris</td>
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</tbody>
</table>
Pop Quiz

11.2 The middle, pigmented layer of the eye is the:
   A) Sclera
   B) Conjunctiva
   C) Retina
   D) Choroid
11.2 The middle, pigmented layer of the eye is the:
A) Sclera
B) Conjunctiva
C) Retina
D) Choroid
The Eye and Vision (cont.)

Pathway of Light Rays and Refraction

- Transparent parts of the eye that refract light
  - Cornea
  - Aqueous humor
  - Crystalline lens
  - Vitreous body
The Eye and Vision (cont.)

Function of the Retina

- Rod cells
  - Function in dim light
  - Not sensitive to color
  - Blurred images

- Cone cells
  - Function in bright light
  - Color-sensitive
  - Sharp images
What anterior structure is continuous with the sclera?
Figure 11-5 The ciliary muscle and lens (posterior view).

What structures hold the lens in place?
Figure 11-6 Accommodation.

A Distant vision

Lateral view

B Close vision

Ciliary muscle (relaxed)
Ciliary body (flattened)
Suspensory ligaments (taut)

Lens (flattened)

Ciliary muscle (contracted)
Ciliary body (bulging)
Suspensory ligaments (relaxed)

Lens (rounded)
What muscle fibers of the iris contract to make the pupil smaller and to make the pupil larger?
The retina.

Figure 11-8 The retina.
The Eye and Vision (cont.)

Checkpoints

11-8 What are the three tunics of the eyeball?

11-9 What are the structures that refract light as it passes through the eye?

11-10 What is the function of the ciliary muscle?

11-11 What is the function of the iris?

11-12 What are the receptor cells of the retina?
The Eye and Vision (cont.)

Disorders of the Eye and Vision

- Errors of refraction
  - Hyperopia
  - Myopia
  - Presbyopia
  - Astigmatism

- Strabismus
  - Convergent
  - Divergent
  - Amblyopia
The Eye and Vision (cont.)

Figure 11-9 Errors of refraction.

A

Hyperopia (farsightedness)

B

Myopia (nearsightedness)

Corrected

Convex lens

Corrected

Concave lens
The Eye and Vision (cont.)

Disorders of the Eye and Vision (cont.)

- Infections
  - Conjunctivitis
  - Inclusion conjunctivitis
  - Neonatal conjunctivitis (ophthalmia neonatorum)

- Injuries
  - Corneal laceration
  - Enucleation
The Eye and Vision (cont.)

Disorders of the Eye and Vision (cont.)

• Cataract

• Glaucoma

• Retinal disorders
  – Diabetic retinopathy
  – Retinal detachment
  – Macular degeneration
Figure 11-10 Retinal disorders.

A - Normal Vision
B - Cataract
C - Diabetic Retinopathy
D - Age-related Macular Degeneration
Figure 11-11  Retinal detachment.
Checkpoints

11-13 What are four errors of refraction?

11-14 What is cloudiness of the lens called?

11-15 What disorder is caused by excess fluid pressure in the eye?
The Ear

Learning Objectives

10. Describe the three divisions of the ear.

11. Describe the receptor for hearing, and explain how it functions.

12. Compare the locations and functions of the equilibrium receptors.
The Ear (cont.)

- Sense organ for hearing and equilibrium

- Components
  - Outer ear
  - Middle ear
  - Inner ear
The Ear (cont.)

The Outer Ear

● Structure
  – Pinna (auricle)
  – External auditory canal (meatus)
  – Ceruminous glands
  – Tympanic membrane

● Function
  – Collects sound waves and transmits sounds to the middle ear
What structure separates the outer ear from the middle ear?
Middle Ear

- **Structure**
  - Ear ossicles
    - Malleus
    - Incus
    - Stapes
  - Auditory tube

- **Function**
  - Amplifies sound waves and transmits sounds to the inner ear
The Ear (cont.)

Inner Ear

- Structure
  - Bony labyrinth; contains perilymph
- Divisions
  - Vestibule
  - Semicircular canals
  - Cochlea
  - Membranous labyrinth; contains endolymph
- Function
  - Transduces sound waves into nerve impulses
What nerve is formed by the merger of the nerves from the inner ear?
The Ear (cont.)

The Steps in Hearing

1. Sound waves enter the external auditory canal.

2. Tympanic membrane vibrates.

3. Stapes transmits the vibrations to the oval window of the inner ear, which transmits the sound waves within the vestibular duct.

4. This fluid wave in the vestibular duct sets up vibrations in the membranes of the cochlear duct.

5. The cochlear duct vibrations initiate a second fluid wave in the tympanic duct.

6. Vibrations in the cochlear duct membrane move the cilia back and forth.

7. This motion sets up nerve impulses that travel to the brain.
Equilibrium

- Ciliated equilibrium sensory receptors are located in vestibule and semicircular canals.

- Types of receptors
  - Maculae
  - Cristae

- Nerve supply via vestibular nerve
What membrane contains the cilia of the hair cells?
What happens to the cilia of the macular cells when the fluid around them moves?
The Ear (cont.)

Checkpoints

11-16 What are the three divisions of the ear?
11-17 What are the names of the ear ossicles, and what do they do?
11-18 What are the two fluids found in the inner ear, and where are they located?
11-19 What is the name of the hearing organ, and where is it located?
11-20 Where are the receptors for equilibrium located?
The Ear (cont.)

Disorders of the Ear

- Ear infection
  - Otitis media
  - Otitis externa

- Hearing loss
  - Conductive hearing loss
  - Sensorineural hearing loss
  - Presbycusis

- Equilibrium disturbances
  - Vertigo
The Ear (cont.)

Figure 11-15 Action of the vestibular equilibrium receptors (maculae).

What happens to the cilia of the macular cells when the fluid around them moves?
The Ear (cont.)

**Figure 11-16** Action of the equilibrium receptors (cristae) in the semicircular canals.
The Ear (cont.)

Checkpoints

11-21  What are the two types of hearing loss?

11-22  What is the term for an abnormal sensation of spinning?
The Ear (cont.)

Pop Quiz

11.3 The ear ossicle that is in contact with the tympanic membrane is the:

A) Malleus
B) Incus
C) Meatus
D) Stapes
Pop Quiz Answer

11.3 The ear ossicle that is in contact with the tympanic membrane is the:

A) Malleus
B) Incus
C) Meatus
D) Stapes
Other Special Sense Organs

Learning Objective

14. Discuss the locations and functions of the sense organs for taste and smell.
Other Special Sense Organs (cont.)

- Taste and smell sense organs respond to chemical stimuli.
Other Special Sense Organs (cont.)

**Sense of Taste (Gustation)**

- Receptors (taste buds)
  - Sweet
  - Salty
  - Sour
  - Bitter
  - Umami

- Nerve supply
  - Facial nerve
  - Glossopharyngeal nerve
Other Special Sense Organs (cont.)

Sense of Smell (Olfaction)

• Smell receptors in the nasal cavity
  – Stimulated by substances in solution in nasal fluids.
  – Smells stimulate appetite and flow of digestive juices.

• Olfactory nerve (cranial nerve I)
Other Special Sense Organs (cont.)

Figure 11-17 Taste.

A Papillae

B A papilla, illustrating the taste buds

C Anatomy of a taste bud
Figure 11-18 Smell.

A The olfactory epithelium

To olfactory cortex, limbic system

B Olfactory neurons
What are the special senses that respond to chemical stimuli?
The General Senses

Learning Objectives

15. Describe five general senses.

16. List five approaches for treatment of pain.
The General Senses (cont.)

- Receptors scattered throughout the body sense
- Touch
- Pressure
- Heat
- Cold
- Position
- Pain
The General Senses (cont.)

Sense of Pain

- Pain receptors
  - Are free nerve endings
  - Are found in skin, muscles, joints, and (to a lesser extent) in most internal organs

- Pain relief
  - Analgesic drugs
  - Anesthetics
  - Endorphins
  - Heat or cold
  - Relaxation or distraction techniques
Sensory Adaptation

- Occurs when receptors are exposed to continuous stimulus.

- Some receptors can adjust themselves, so sensation becomes less acute.

- Receptors adapt at different rates.

- Pain receptors do not adapt.
Sensory Adaptation (cont.)

Figure 11-19 Sensory receptors in the skin.
The General Senses

Checkpoints

11-24  What are five examples of general senses?

11-25  What are proprioceptors, and where are they located?
The General Senses (cont.)

Pop Quiz

11.4 If you hold your arm motionless in the air, which receptors are most important in informing you of your hand position?

A) Proprioceptors
B) Pressure receptors
C) Tactile corpuscles
D) Free nerve endings
The General Senses (cont.)

Pop Quiz Answer

11.4 If you hold your arm motionless in the air, which receptors are most important in informing you of your hand position?

A) Proprioceptors
B) Pressure receptors
C) Tactile corpuscles
D) Free nerve endings
Learning Objective

17. Referring to the case study, discuss the purpose and mechanism of a cochlear implant.
Case Study (cont.)

Cochlear Implant

- A small surgically implanted electronic device that can help to provide a sense of sound to someone with sensorineural hearing loss and who is profoundly deaf or severely hard of hearing.
- Implant candidacy takes into account a person's hearing history, cause of hearing loss, amount of residual hearing, speech recognition ability, health status, and family commitment to aural habilitation/rehabilitation.
- Does not cure deafness but rather may be considered a prosthetic substitute for hearing.
Case Study (cont.)

Diagnosis

● The inner part of the ear contains tiny hair cells (cilia) that change sounds into electric signals. The nerves carry these signals to the brain.
● Sensorineural hearing loss is caused by damage to these special cells in the inner ear.
● Vibrations in the cochlear duct membrane move the cilia back and forth, which set up the nerve impulses for hearing that travel to the brain.
● Bacterial meningitis destroyed the hair cells in Evan’s cochlea causing the hearing impairment.
● The strong drugs used to treat the meningitis may have been ototoxic contributing to further destruction of the hair cells.
Case Study (cont.)

Treatment

- Cochlear implant
  - Stimulates the cochlear nerve directly, bypassing the damaged receptor cells
  - Three components:
    • Internal receiver with electrodes going to the inner ear
    • Transmitter
    • Sound processor
  - Three components allow the brain to interpret the frequency of sound as if the hair cells were functioning properly.
- Postimplant follow-up with a speech therapist and audiologist
18. Show how word parts are used to build words related to the sensory system.
### Word Anatomy (cont.)

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<thead>
<tr>
<th>Word Part</th>
<th>Meaning</th>
<th>Example</th>
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<tbody>
<tr>
<td><strong>The Eye and Vision</strong></td>
<td></td>
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<tr>
<td>ambly/o</td>
<td>dimness</td>
<td><em>Amblyopia</em> is poor vision in a healthy eye that cannot work properly with the other eye.</td>
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<tr>
<td>e-</td>
<td>out</td>
<td><em>Enucleation</em> is removal of the eyeball.</td>
</tr>
<tr>
<td>lute/o</td>
<td>yellow</td>
<td>The macula <em>lutea</em> is a yellowish spot in the retina that contains the fovea centralis.</td>
</tr>
<tr>
<td>ophthalm/o</td>
<td>eye</td>
<td>An <em>ophthalmologist</em> is a physician who specializes in treatment of the eye.</td>
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<tr>
<td>-opia</td>
<td>disorder of the eye or vision</td>
<td><em>Hyperopia</em> is farsightedness.</td>
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<tr>
<td>presby-</td>
<td>old</td>
<td><em>Presbyopia</em> is farsightedness that occurs with age.</td>
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<tr>
<td>-scope</td>
<td>instrument for examination</td>
<td>An <em>ophthalmoscope</em> is an instrument used to examine the posterior of the eye.</td>
</tr>
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<td>Word Part</td>
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<tr>
<td><strong>The Ear</strong></td>
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<tr>
<td>-cusis</td>
<td>hearing</td>
<td><em>Presbycusis</em> is hearing loss associated with age.</td>
</tr>
<tr>
<td>equi-</td>
<td>equal</td>
<td><em>Equilibrium</em> is balance (&quot;equi-&quot; combined with Latin word <em>libra</em> meaning &quot;balance&quot;).</td>
</tr>
<tr>
<td>-lith</td>
<td>stone</td>
<td><em>Otoliths</em> are small crystals in the inner ear that aid in static equilibrium.</td>
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<tr>
<td>myring/o</td>
<td>tympanic membrane</td>
<td><em>Myringotomy</em> is a cutting of the tympanic membrane to relieve pressure.</td>
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<tr>
<td>ot/o</td>
<td>ear</td>
<td><em>Otitis</em> is inflammation of the ear.</td>
</tr>
<tr>
<td>-stomy</td>
<td>creation of an opening</td>
<td>A <em>tympanostomy</em> tube creates a passageway between two structures through the tympanic membrane.</td>
</tr>
<tr>
<td>tympan/o</td>
<td>drum</td>
<td>The <em>tympanic</em> membrane is the eardrum.</td>
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# Word Anatomy (cont.)

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<tr>
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<tbody>
<tr>
<td><strong>The General Senses</strong></td>
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<tr>
<td>alges/i</td>
<td>pain</td>
<td>An analgesic is a drug that relieves pain.</td>
</tr>
<tr>
<td>-esthesia</td>
<td>sensation</td>
<td>Anesthesia is a loss of sensation as of pain.</td>
</tr>
<tr>
<td>kine</td>
<td>movement</td>
<td>Kinesthesia is a sense of body movement.</td>
</tr>
<tr>
<td>narc/o</td>
<td>stupor</td>
<td>A narcotic is a drug that alters the perception of pain.</td>
</tr>
<tr>
<td>propri/o</td>
<td>own</td>
<td>Proprioception is perception of one’s own body position.</td>
</tr>
</tbody>
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